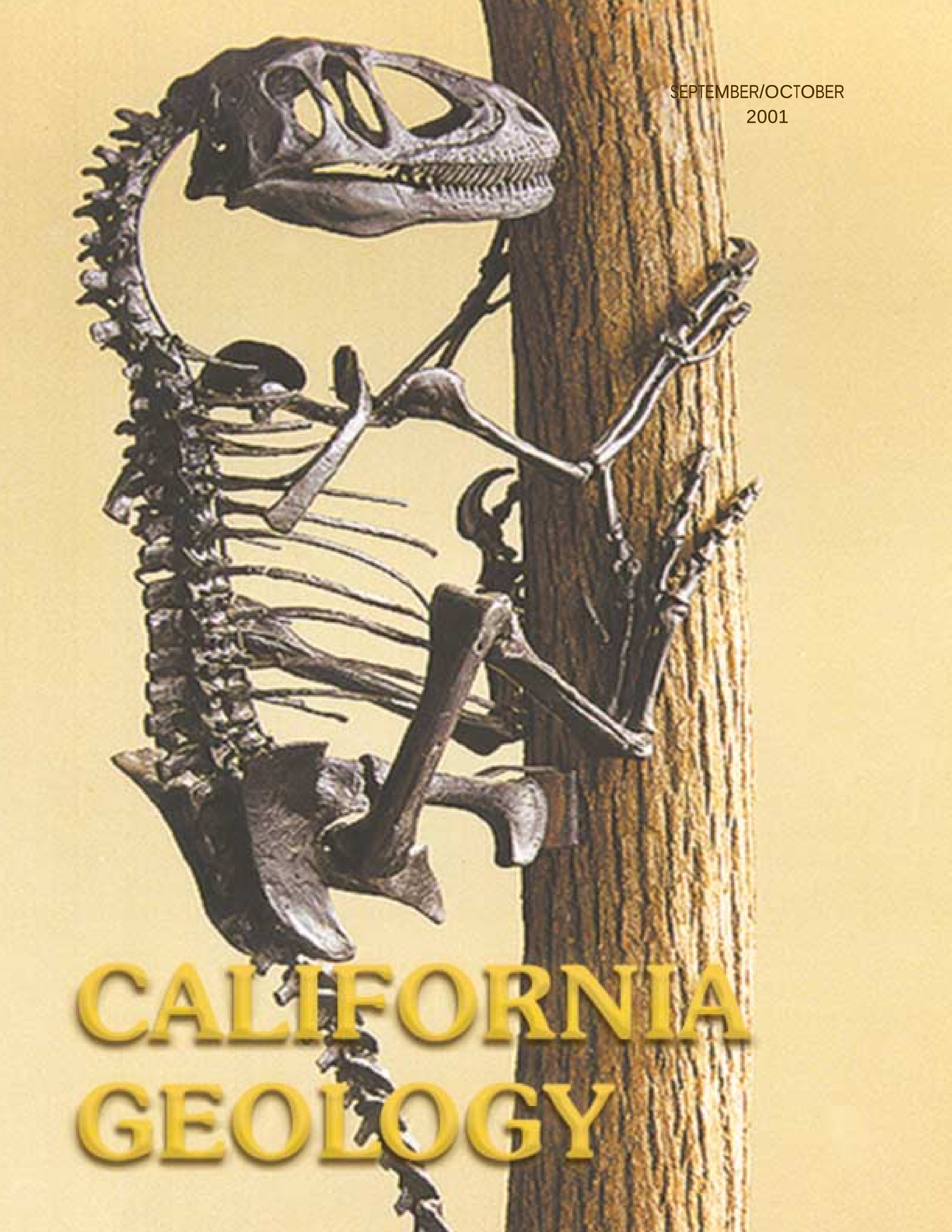
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Cover Photo:
Deinonychus antirrhopus, cast of skeleton. Discovered by Ostrom, 1969.

Location: Clovery Formation; Wyoming, Montana, North America.

Age: Early Cretaceous, 110 million years ago. This is a new reconstruction of the *Deinonychus* mode of living and skeleton construction made by Dr. A. Karhu. This bipedal predator is undoubtedly one of the most spectacular dinosaurs. He (or she?) was medium-sized, lightly-built and agile. Strong grasping hands were furnished with large sharp claws. The relatively long tail was stiffened by long ossified tendons. The most notable feature of *Deinonychus* was a large scimitar-like talon on the second toe.

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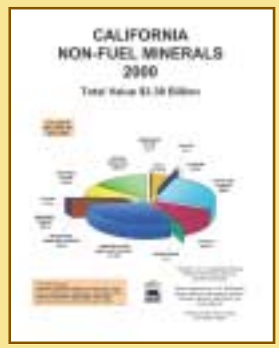

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RUSSIAN DINOSAURS

THE EXHIBITION

Just recently allowed outside Russia, this spectacular collection of 60 fossils (including 33 complete skeletons) is on display in Sacramento, California. It's the largest traveling dinosaur exposition in the world. The fossils are on loan from the Paleontological Institute of the Russian Academy of Sciences in Moscow. These 60 fossils are just a small sampling of the Institute's extensive collection. The Sacramento exhibition spans some 250 million years of history, featuring specimens from the Late Permian through the Late Cretaceous. The specimens are unique in their diversity and exceptional state of preservation. The collection consists of 85% original fossils, and includes some first discovered, best known, and one-of-a-kind specimens.

Throughout the exhibition's stay in Sacramento, a team of paleontologists from the Institute will offer lectures and answer questions at pre-selected times.

Tarbosaurus (*Tyrannasaurus*) baatar. Juvenile skeleton, skull, forelimb, brain case. *Photo by Max Flanery.*

IN SACRAMENTO

On the following pages we present a sampling of the Russian Dinosaur Exhibition. . .

THE SCIENTISTS

(left to right) Dr. Evgeny N. Kurochkin, Chief of the Paleoornithological Laboratory at the Paleontological Institute, Dr. Alexei Yu Rozanov, Director of the Paleontological Institute, Russian Academy of Sciences, and Dr. Natalia Stchstlivtseva, Museum Director of the Paleontological Institute, Russian Academy of Sciences. *Photo by Max Flanery.*

Avimimus portentosus

Discovered by Kurzanov, 1981

Locality: Udan Sayr, Gobi Desert, southern Mongolia

Age: Late Cretaceous (Campanian), 75 million years ago

This very unusual dinosaur shares some characteristics of the forelimb and shoulder girdle with birds. Small carnivorous dinosaurs or theropods are thought to have given rise to birds. The translation of *Avimimus* is bird mimic. Dr. Sergey Kurzanov interpreted it as a dinosaur that had features in parallel with birds, perhaps even feathers. The animal may have had short, wide wings of limited use for flight and been warm blooded.

Protoceratops andrewsi

Discovered by Granger and Gregory, 1923

Locality: Tugrikin Us, Gobi Desert, southern Mongolia

Age: Late Cretaceous (Campanian), 75 million years ago

Protoceratops egg nest.

Protoceratops andrewsi is one of the best known dinosaurs. Literally hundreds of individuals have been collected in central Asia. Sometimes this species makes up more than 80% of all the dinosaurs known from a site. All states of growth are known from unhatched eggs containing embryos to hatchlings to teenagers to adults. Because so many stages of life of this sheep-sized dinosaur are known, paleontologists understand how the skeleton changed throughout the life of the individual—something quite rare to know about fossil animals. *Protoceratops* seems to have lived in large groups, perhaps forming nestling colonies along the shores of ancient lakes and streams in an otherwise arid landscape. The catastrophes that can occur in such an environment, such as flash floods or extended drought, coupled with the natural instinct of these dinosaurs to congregate, probably led to the unusual abundance of this group in the fossil record. Although *Protoceratops* is a neoceratopsian (a group of dinosaurs that typically has horns) there were none on this species, just low bony knobs of bone on the skull. The descendants of *Protoceratops* probably emigrated from Asia to North America where they eventually gave rise to such well-known dinosaurs as *Triceratops*, which did have horns.

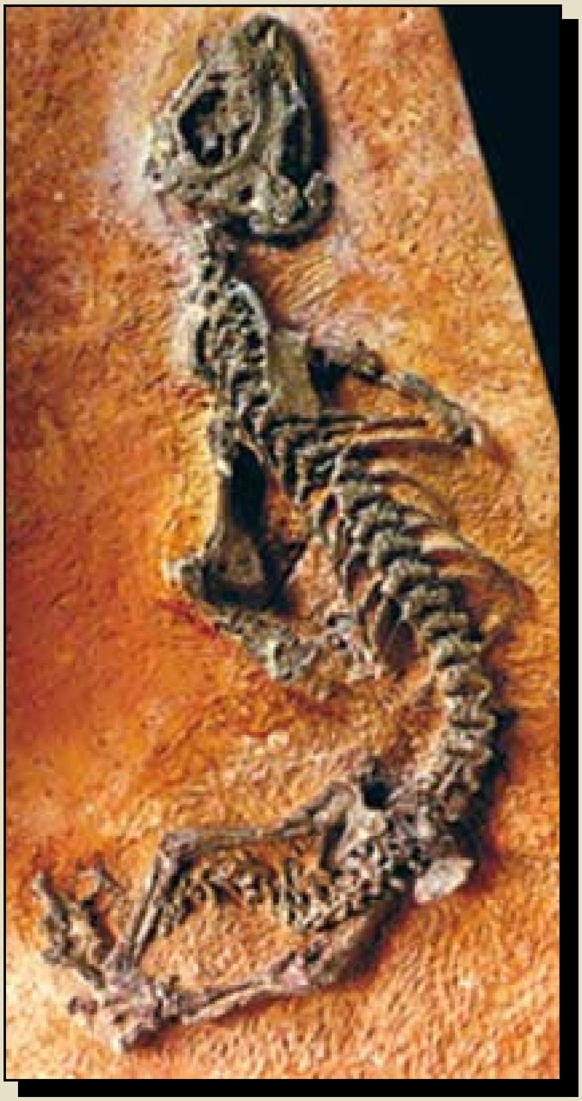
Baby *Protoceratops.*

Nyctiphruretus acudens

Discovered by Efremov, 1938

Locality: Mezen River, Arkhangelsk Region, northern European Russia

Age: Late Permian, 260 million years ago



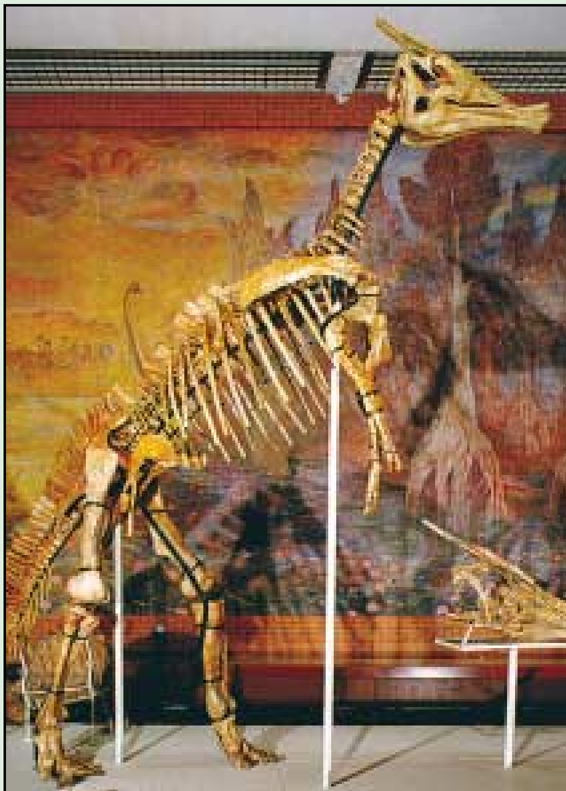
In the Paleozoic, the land looked very different than it does today, and terrestrial tetrapods inhabited unusual environments. These "extinct landscapes" existed in the huge megacontinents, southern Gondwana and northern Laurasia, separated by the ancient ocean Tethys. In the early Late Permian, a swampland existed in what is now Eastern Europe around an extensive shallow gulf of the Boreal Ocean. This gulf is called the East European Sea. Its western coast was a very broad flattened lowland flooded from time to time by high sea tides. The coasts of numerous shallow lakes, covered by soft silt, were inhabited by ancient animals. This area yielded many specimens of the small lizard-like *Nyctiphruretus*; hundreds of skeletons have been found in all stages of growth. *Nyctiphruretus* fed on aquatic vegetation.

Saurolophus angustirostris

Discovered by Rozhdestvensky, 1957

Locality: Altan Ula, Nemegt Basin, Gobi Desert, southern Mongolia

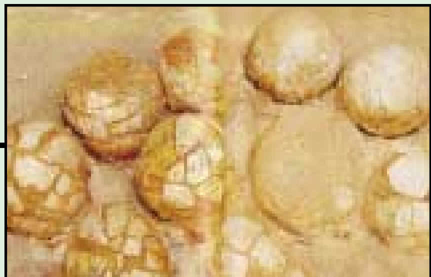
Age: Late Cretaceous (Late Campanian), 74 million years ago



Saurolophus is one of the largest hadrosaurids, or duck-billed dinosaurs. The toothless anterior parts of the jaws in the *Saurolophus* were flattened and widened, like a duck bill. At the same time, the numerous lateral teeth were well-developed, so the animal could cut and chew aquatic vegetation, which was probably its regular forage. Indeed, both the vertically-flattened tail and wide paws suggest that *Saurolophus* dwelled in shoals and coastal environments. The posterior part of the skull roof forms a long backward directed spine with inner hollows connected to aerial ducts. Many paleontologists think these hollows might be acoustic resonators that could reinforce vocalization. Relatively well-developed forelimbs in *Saurolophus* suggests it was quadrupedal when moving slowly, but bipedal when traveling faster. This dinosaur is also well-known in North America, where, as in Mongolia, it's common in flood plain deposits.

Skin impressions of hadrosaurs are rather common in North America and Central Asia. They show these animals had a scale pattern typical of reptiles. There's no suggestion of hair, feathers, or any other insulating external body covering.

Saurolophus angustirostris-Rozhdestvensky, 1957- fragment of fossil skin.



Nest of hadrosaur eggs.

Saurolophus angustirostris. Photo by Max Flanery.

Location:
until December 31, 2001 the Russian Dinosaur Exhibition will be at

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For more information or to schedule a group or field trip, call:

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Prismatic International, Inc.

Prismatic International, Inc. works with Sacramento-area school districts to ensure that students from pre-school to university levels have the opportunity to see the exhibition and learn about the world's pre-history. While special emphasis is directed toward the academic community, Prismatic offers this exceptional dinosaur collection to everyone.

Estemmenosuchus uralensis and friends. *Photo by Max Flanery.*

Estemmenosuchus uralensis. 255 million years ago. A large omnivore that may have been warm-blooded. *Photo by Max Flanery.*

Appreciation goes to Deborah Greco and Hal Morrison of Prismatic International, Inc. and Barry Hudson of BearFacts, Inc. for guiding us through, and sharing insights about this exhibition. Information from the website and other Prismatic materials greatly benefited this article.

Sincere thanks to Dr. Rozanov, Dr. Stchstlivtseva and Dr. Kurochkin for answering a multitude of questions about this exhibition and the world of paleontology.

The Paleontological Institute of the Russian Academy of Sciences, Moscow

The Institute is among the largest paleontological museums in the world. The Moscow museum opened in 1937, but its history goes back to the Kunstkamer founded by Peter the Great in St. Petersburg in 1716. The Kunstkamer, the first public museum in Russia, was destined to house a collection of rarities, including some mammalian fossils of the Ice Age. As with other world-class museums, the Institute displays only a small fraction of its vast collection. The dinosaur specimens are collected from many regions of Russia, the former Soviet Republics, as well as Mongolia and China.

Fluid-Inclusion Studies of Hydrothermal Minerals from Geothermal Drill Holes at Medicine Lake Volcano, Northern California

By
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Figure 1. Location map of Medicine Lake volcano, northern California in relation to other volcanoes of the Cascade Mountain Range (shaded areas).

INTRODUCTION

Medicine Lake volcano is a large (about 2,000 kilometer^2 [km]) Pleistocene to Holocene volcano in the Cascade Range of northern California about 50 km east-northeast of Mount Shasta (Figure 1) (Donnelly-Nolan, 1988, 1990). The accumulation of lava flows that comprise this low, broad, shield-shaped volcano probably began erupting about 1 million years ago (Donnelly-Nolan and others, 1990). At least 17 eruptions have occurred at Medicine Lake volcano during the past 12,000 years; composition of these lava flows ranges between basalt (< 52% SiO_2) and rhyolite (> 72% SiO_2) with only scarce dacite (62-67% SiO_2) lavas (Donnelly-Nolan and others, 1990). The most recent volcanic activity (about 900 years ago), at Glass Mountain and Little Glass Mountain, occurred in the vicinity of the 7 x 12 km caldera (depression due to collapse of volcano's summit following an eruption) (Figure 2) (Donnelly-Nolan and others, 1990).

Owing to this recent volcanism, Medicine Lake volcano was viewed as a possible resource for geothermal energy (energy derived from underground hot fluids, commonly associated with active volcanic regions, which are used in driving generators to produce electricity). As such, over the past couple of decades, various private companies have invested considerable effort in trying to determine the geothermal energy potential of the area. Industry evaluation of the volcano included completion of several drill holes. Initially, results of the drilling mostly were proprietary; however, drill-core samples from 12 holes were made available for scientific investigations. In

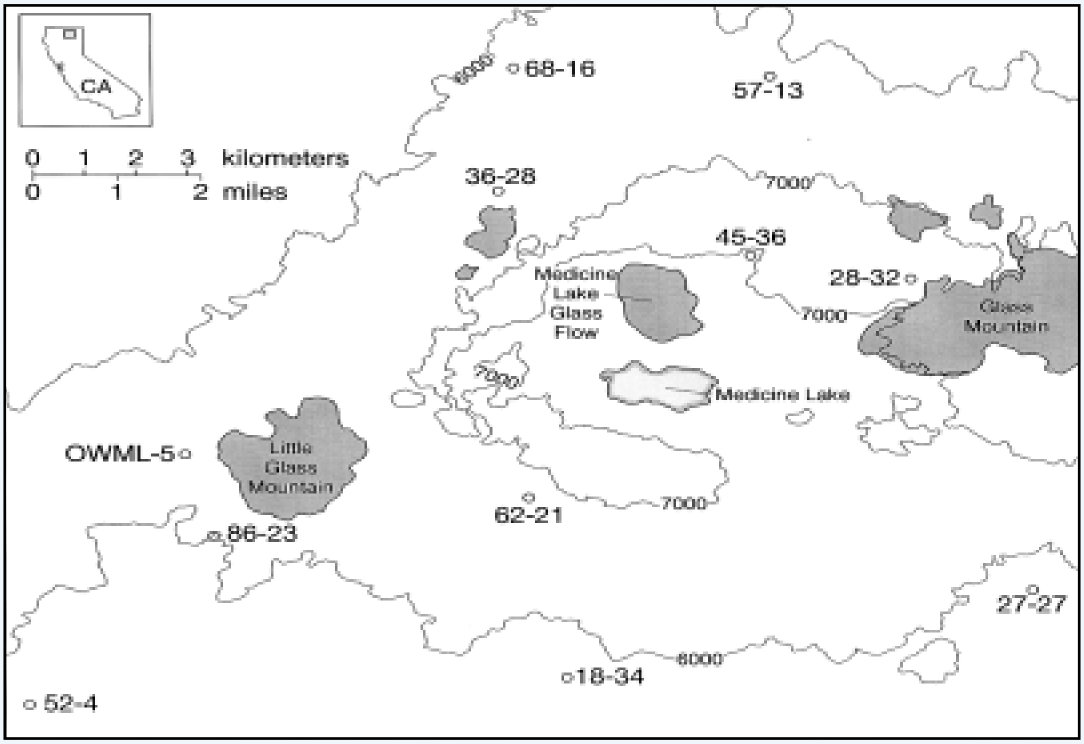


Figure 2. Topographic map of Medicine Lake volcano, northern California showing the location of 11 of the 12 geothermal prospect drill holes (open circles) included in this study. Drill hole ML 88-12 is about 10 km west of the ML 52-4 drill hole. The rim of the caldera lies within the closed 7,000 foot contour lines. Shaded areas are Holocene volcanic deposits.

1992, a group of interested U.S. Geological Survey scientists took advantage of this unique opportunity to examine the extensive collection of drill-core specimens. As a member of this group, my interest was in obtaining information on past and present-day temperatures of the thermal fluids circulating through rocks penetrated by the drill holes.

Prior to this investigation, some general information on the petrology of eight flank drill holes was provided by Donnelly-Nolan (1990). A temperature of 105ºC at 1.2 km depth and a geothermal gradient of 100ºC/km between depths of 0.5 and 1.2 km were reported for the ML 88-12 drill hole (not shown in Figure 2) located about halfway between Mount Shasta and the Medicine Lake volcano (Blackwell and others, 1990). Also, measured geothermal gradients of 88ºC/km, 227ºC/km, and 548ºC/km were given for three wells sited within the volcano's caldera (Donnelly-Nolan and others, 1990).

HYDROTHERMAL MINERALOGY

More than 600 representative core specimens from the 12 drill holes, which range in depth from about 340 m to 1,370 m (see Figure 2 for locations of all but the ML 88-12 hole), were collected for this study. Some volcanic glass, and open spaces of many fractures, vesicles, and areas between fragments of breccias in core specimens from all 12 drill holes show alteration effects caused by circulating thermal fluids. This study of drill-hole samples from the Medicine Lake volcano area identified 44 metamorphic minerals (zeolites, carbonates, sheet-silicates, silica minerals, sulfides, sulfates, and other minerals) (Table 1) that formed by hydrothermal (hot water) alteration of preexisting rocks at low (< ~200ºC) to moderate (~200º to 400ºC) temperatures (Bargar and Keith, 1993). Table 1 shows the temperatures at which these minerals have been found in well-studied geothermal systems throughout the world. Many of the hydrothermal minerals identified from the drill holes must have formed at temperatures below 200ºC. Only rocks near the bottoms of the two intracaldera drill holes (ML 28-32 and ML 45-36) display more intense alteration reflective of exposure to higher-temperature fluids. The presence of minerals such as garnet, epidote, actinolite, prehnite, and talc indicates that past downhole temperatures have been in the range of 200ºC to more than 300ºC. A few additional minerals listed in Table 1 could possibly have been deposited at temperatures above 200ºC. More specific temperature data for the two intracaldera drill holes can be determined from minerals containing fluid inclusions (microscopic cavities in the crystals filled by water and gas phases that were trapped during or following crystal formation) such as quartz, calcite and possibly wairakite. In addition to providing a probable temperature range over which the minerals formed, fluid inclusions also may be used to determine the salinity of the fluids from which the crystals precipitated.

Table 1. Hydrothermal minerals identified from geothermal drill holes at Medicine Lake volcano and the temperatures at which these minerals are found in studied modern geothermal areas.

Drill hole no.	OWML5	18-34	27-27	28-32	36-28	45-36	52-4	57-13	62-21	68-16	86-23	88-12	Temp.[2]
Zeolite minerals													
Analcime	--	--	--	--	--	--	--	--	--	--	X	--	70—300
Chabazite	X	--	--	--	--	--	X	--	--	--	--	--	<75
Heulandite	X	--	--	X	--	X	X	--	X	--	--	--	60—170
Laumontite	--	--	--	X	--	X	--	--	--	--	--	X	43—230
Levyne	--	--	--	--	--	--	--	--	--	--	X	--	<70
Mordenite	--	--	--	X	--	X	X	--	X	--	--	--	85—230
Phillipsite	--	X	--	--	--	--	--	--	--	--	X	--	37—85
Scolecite	--	--	--	--	--	--	--	--	--	--	X	--	65—100
Stilbite	X	--	--	--	--	--	X	--	--	--	X	--	70—170
Thomsonite	--	--	--	--	--	--	--	--	--	--	X	--	60—110
Wairakite	--	--	--	X	--	X	--	--	--	--	--	--	180—300
Carbonate minerals													
Aragonite	--	--	--	X	--	--	--	--	--	--	--	--	<80
Calcite	X	X	X	X	X	X	X	X	X	--	X	X	<100—350
Dolomite	X	--	--	X	--	--	--	--	X	--	--	--	<10—250
Kutnohorite	--	--	X	X	--	--	--	--	--	--	--	--	<10—70
Rhodochrosite	--	--	--	--	--	X	--	--	--	--	--	--	30—130
Siderite	X	X	--	X	--	--	X	--	--	--	--	--	<10—160
Sheet-silicate minerals													
Kaolinite	--	--	--	X	--	--	--	--	--	--	--	--	<50—170
Halloysite	--	--	--	--	--	--	X	--	--	--	--	--	<50
Smectite	X	X	X	X	X	X	X	X	X	--	X	X	<200
Illite-Smectite	--	--	X	X	--	--	--	--	--	--	--	X	50—270
Illite	--	--	--	X	--	X	--	--	--	--	--	--	150—<300
Chlorite-Smectite	--	--	--	X	--	X	--	--	--	--	--	--	<100—240
Chlorite	--	--	--	X	--	X	--	--	--	--	--	X	<100—350
Apophylite	--	--	--	--	--	--	--	--	--	--	X	--	50—70
Prehnite	--	--	--	--	--	X	--	--	--	--	--	--	210—350
Talc	--	--	--	X	--	--	--	--	--	--	--	--	290—320
Silica minerals													
Opal	--	--	--	--	--	X	--	--	--	--	--	--	<100
Cristobalite	X	--	--	X	--	X	X	--	X	--	--	--	<100—210
Chalcedony	X	--	--	X	--	X	X	--	X	--	--	--	<100—240
Quartz	X	--	--	X	X	X	--	--	X		--	X	100—300+
Sulfide minerals													
Marcasite	--	--	--	X	X	--	--	--	--	--	--	--	80—170
Pyrite	--	--	--	X	X	X	X	--	--	--	--	X	<100—350+
Pyrrhotite	--	--	--	X	--	X	--	--	--	--	--	--	97—265
Sulfate minerals													
Anhydrite	--	--	--	X	--	X	--	--	--	--	--	--	60—300
Gypsum	--	--	--	X	X	--	--	--	--	--	--	--	<70
Natrojarosite	--	--	--	X	X	--	--	--	--	--	--	--	50
Other minerals													
Iron oxide[1]	X	X	--	X	--	X	X	--	X	X	--	X	<100—250
Magnetite	--	--	--	X	--	--	--	--	--	--	--	--	>200?
Gyrolite	--	--	--	--	--	--	--	--	--	--	X	--	<50—>200
Adularia	--	--	--	X	--	--	--	--	--	--	X	--	150—300+
Actinolite	--	--	--	X	--	X	--	--	--	--	--	--	260—400
Epidote	--	--	--	X	--	X	--	--	--	--	--	--	220—350
Garnet	--	--	--	X	--	--	--	--	--	--	--	--	250—300+

[1]Iron oxide includes both amorphous iron oxide and hematite in XRD analyses.

[2]Measured temperatures (in °C) at which minerals occur in modern geothermal areas. Data from Tómasson and Kristmannsdóttir (1972); Kristmannsdóttir (1975); Kristmannsdóttir and Tómasson (1978); Kristmannsdóttir (1979); Jakobsson and Moore (1986); Fridleifsson (1991); Honda and Muffler (1970); Keith, White, and Beeson (1978); Holland and Malinin (1979); Elders and others (1979); Cavarretta, Gianelli, and Puxeddu (1982); Leach, Wood, and Reyes (1983); Aumento and Liguori (1986); Hulen and Nielson (1986); White, Hutchinson, and Keith (1988); Horton (1985); Bargar and Keith (1999); McDowell and Paces (1985).

Fluid Inclusion Data

Doubly polished (polished on both sides) thin sections of hydrothermal quartz, calcite, and wairakite crystals, along with a few unpolished, thin, calcite cleavage chips were used for fluid-inclusion analyses in this study. Very thin chips of the minerals are heated on a microscope stage to the temperature at which the liquid and gas phases inside the fluid inclusions merge by expansion or contraction to a single phase (either gas or liquid). This is called the homogenization temperature (Th) and is generally presumed to be the minimum formation temperature of the fluid inclusion (Roedder, 1984). The fluid inclusions also are frozen on the microscope stage and then gradually thawed; the temperature at which the last piece of ice melts (Tm) is recorded. This ice-melting temperature can be used to determine the salinity (in weight % NaCl equivalent) of the fluid from which the crystals precipitated (Potter and others, 1978). Successive calibration runs (for the Linkam THM 600 heating/freezing microscope stage and TMS 90 temperature control system), using synthetic fluid inclusions (Bodnar and Sterner, 1984) and chemical compounds with known melting points recommended in Roedder (1984), suggest that the accuracy of the Th measurements is within ± 2.0ºC and the Tm values are accurate to at least ± 0.2ºC.

Fluid-inclusion data were only obtained for quartz, calcite, and wairakite from the two geothermal drill holes (ML 28-32 and ML 45-36) that were completed within the caldera of Medicine Lake volcano. Hydrothermal quartz crystals occur in open spaces of six drill holes, calcite was found in all but one drill hole, and wairakite was identified only in the two intracaldera holes (Table 1). Calcite and wairakite are colorless to white soft minerals for which leakage of fluid from the inclusions potentially could result in erroneous fluid-inclusion data; on the other hand, quartz is a colorless hard mineral that generally is not believed to leak and is regarded as a very good mineral for fluid inclusion analyses (Roedder, 1984). Most fluid inclusions appear to have formed along healed fractures and are classified as being of secondary origin. Many similar inclusions are referred to as pseudosecondary because later mineral growth on exterior crystal faces sealed off healed fractured zones leaving crystal rims free of fluid inclusions. A few inclusions are very large compared with the size of the host crystal and appear to be isolated from other fluid inclusions; such inclusions are classified as primary because they must have formed during initial crystal growth. Quartz specimens first were frozen and gradually thawed to obtain the Tm values; these specimens were then heated to record the Th data. The order of heating and freezing was reversed for the soft calcite and wairakite minerals because of the possibility that expansion of ice in fluid inclusions of these minerals might cause the inclusions to break.

Drill hole ML 28-32

Homogenization temperatures (Th) were obtained for 94 liquid-rich, secondary and pseudosecondary, fluid inclusions in quartz specimens

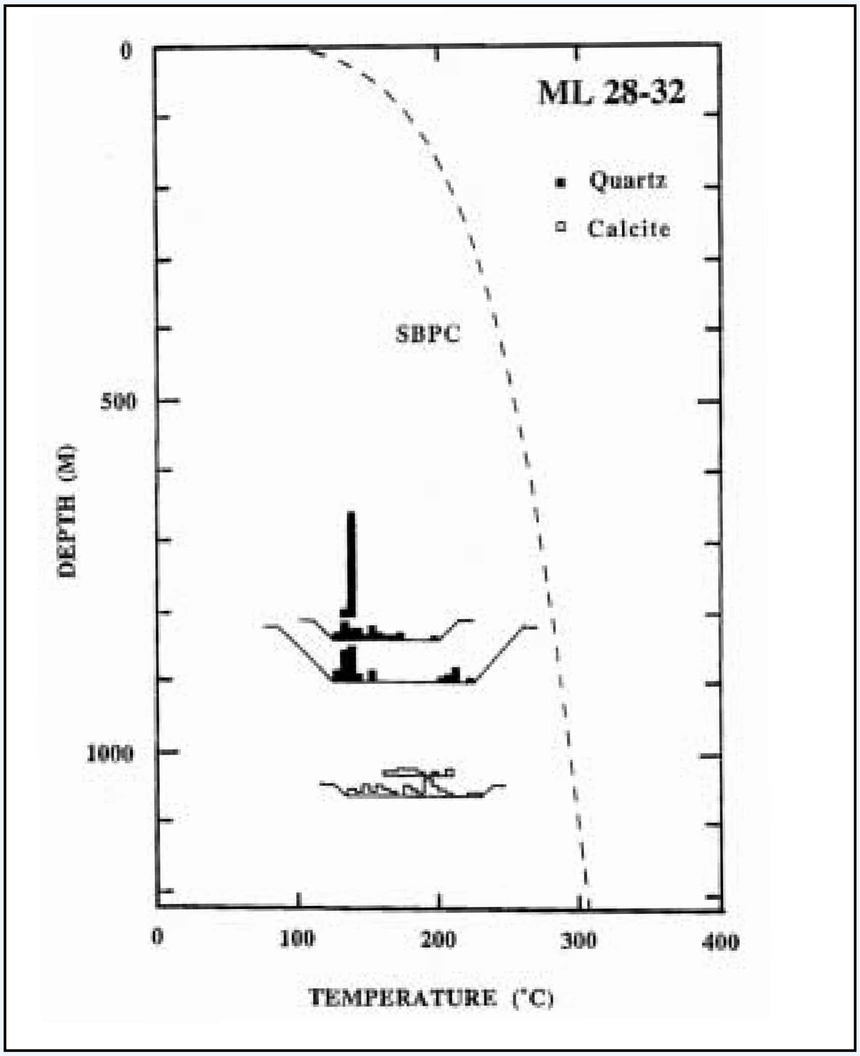


Figure 3. Plot of depth below ground surface vs. fluid-inclusion homogenization temperatures (Th) for fluid inclusions in hydrothermal quartz and calcite minerals in core from the ML 28-32 drill hole (data from Table 2). Dashed curve is a theoretical reference boiling-point curve for pure water originating at the ground surface (after data in Elder, 1981, Table A5).

Table 2. Fluid-inclusion heating/freezing data for hydrothermal minerals in geothermal drill core from Medicine Lake volcano

Sample depth (m)	Host mineral	Number of melting-point temperature measurements	Melting-point temperatures T_m (˚C)	Salinity (wt percent NaCl equiv-alent)	Number of homogenization temperature measurements	Range of homogenization temperatures T_h (˚C)	Mean homogenization temperature T_h (˚C)
Drill hole ML 45-36							
432.5	quartz	1	0.0	0.0	1	150	—
753.8	"	33	0.0, -0.1	0.0, 0.2	51	211 – 324	268
827.2	"	15	0.0, -0.1	0.0, 0.2	28	198 – 324	259
841.6	"	19	0.0, -1.7	0.0, 2.9	27	227 – 312	254
854.4	calcite	0	—	—	25	178 – 213	188
855.0	quartz	29	0.0, -0.1	0.0, 0.2	53	189 – 304	268
856.2	"	33	0.0, -0.1	0.0, 0.2	56	197 – 373	244
1011.0	calcite	30	0.0, -1.1	0.0, 1.9	46	202 – 285	249
1184.8	wairakite	0	—	—	4	194 – 263	211
Drill hole ML 28-32							
804.1	quartz	0	—	—	31	130 – 138	136
811.2	"	8	-0.5, -0.6, +4.1		26	125 – 196	147
819.8	"	16	-0.2, -0.4, -0.5 -0.9, -1.2, +2.6 +3.1, +3.2		37	127 – 223	154
1030.2	calcite	0	—	—	12	163 – 207	183
1043.9	"	0	—	—	32	139 – 225	177

from three depths in the ML 28-32 drill hole; the Th values range between 125º and 223ºC (Table 2; Figure 3). Only 24 melting-point temperature (Tm) measurements were obtained for these fluid inclusions. Some of the analyzed specimens were too murky to determine the temperature at which the last piece of ice melted. The vapor bubble for several fluid inclusions disappeared during freezing and did not reappear until +2.6º to +4.1ºC. These positive Tm values indicate metastability and the fluid inclusions cannot be used for salinity calculations (Roedder, 1984). Other Tm values range between -0.5º and -1.2ºC corresponding to 0.9 to 2.1 weight percent NaCl equivalent. Tm data were not obtained for two calcite cleavage chips; Th values for 44 fluid inclusions in the calcite specimens range between 139º and 225ºC.

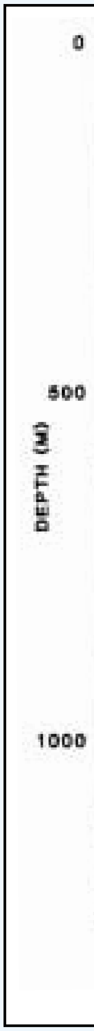
Drill hole ML 45-36

Homogenization temperatures were obtained for 216 liquid-rich, secondary, pseudosecondary, and primary fluid inclusions in quartz crystals that line open spaces in drill core from six depths in the ML 45-36 drill hole (Table 2). Three vapor-rich pseudosecondary fluid inclusions from one specimen also were analyzed; these inclusions homogenized to the vapor state but the precise Th values were not observed. Th measurements for quartz specimens from this drill hole range between 150º and 373ºC (Figure 4). Tm values of 130 fluid inclusions are mostly 0.0º and -0.1ºC corresponding to a salinity of 0.0 to 0.2 weight percent NaCl equivalent. Nine fluid inclusions in one quartz specimen have a Tm value of -1.7ºC, which corresponds to a salinity of 2.9 weight percent NaCl equivalent.

Thirty Tm values were obtained for secondary liquid-rich fluid inclusions in one of two calcite specimens analyzed from this drill hole. Tm measurements for 22 fluid inclusions in one crystal from this specimen were 0.0ºC (salinity = 0.0 weight percent NaCl equivalent). Eight fluid inclusions in a separate calcite crystal from the same specimen had Tm values of -1.1ºC corresponding to a salinity of 1.9 weight percent NaCl equivalent. Th values for 71 analyzed fluid inclusions in the two calcite specimens ranged from 178ºC to 285ºC. Forty-one liquid-rich fluid inclusions in a wairakite specimen mostly leaked during heating. No Tm values were measured for the wairakite fluid inclusions, and only four Th values between 194º and 263ºC were recorded. Reliability of the fluid-inclusion measurements in calcite and wairakite crystals reported here are quite suspect; however, the measured Tm and/or Th values of these inclusions fall within the range of data for the quartz specimens from this drill hole (Figure 4; Table 2) and thus were not eliminated from the data set.

BACTERIA-LIKE PARTICLES

A 2-mm-long, colorless, euhedral, quartz crystal from a fracture in a rhyolitic lava flow from 856.2-m depth in drill hole ML 45-36 contains dozens of bacteria-like moving particles that were trapped within a 200µm x 130µm, liquid-rich, primary fluid inclusion (Photo 1) (Bargar, 1992). The moving particles, ranging in size from <0.5µm (undefined



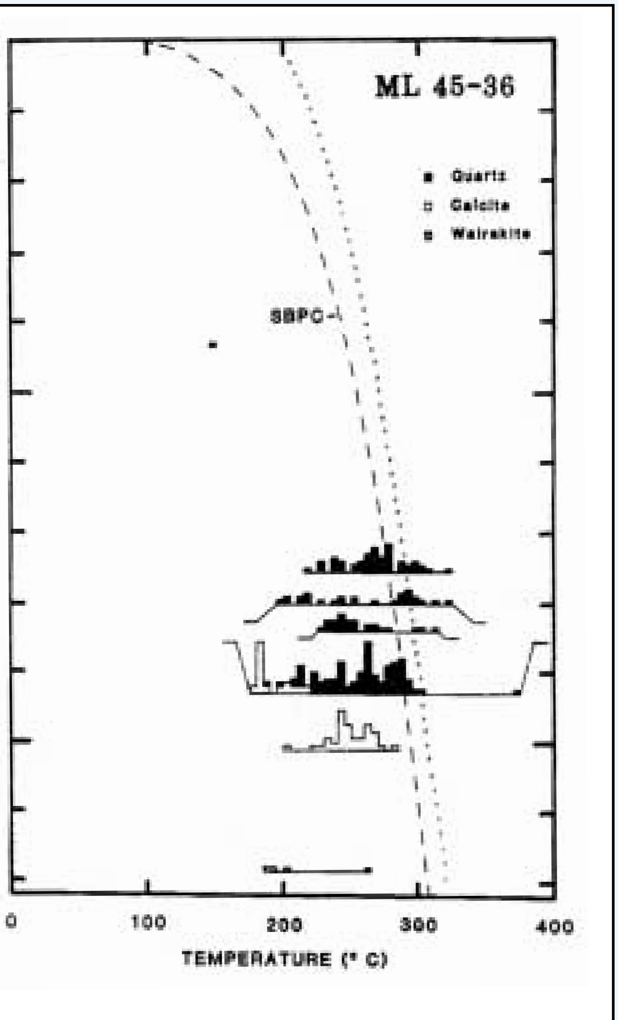


Figure 4. Plot of depth below ground surface vs. fluid-inclusion homogenization temperatures (Th) for fluid inclusions in hydrothermal quartz, calcite, and wairakite minerals from the ML 45-36 drill hole (data from Table 2). Dashed curve is a theoretical reference boiling-point curve for pure water originating at the ground surface (after data in Elder, 1981, Table A5). Dotted curve is a theoretical reference boiling-point curve for pure water originating 150 m above the present-day ground surface assuming the presence of an overburden of this thickness of glacial ice.

shapes) to ~3µm to 5 µm (rodlike) (Photo 2), were first noticed during initial heating of the fluid inclusion. The sub micron-sized particles move very rapidly at ambient temperature while the larger, rod-shaped particles move very sluggishly and are difficult to distinguish among the shadows near the vapor bubble and the outer margins of the fluid inclusion. Around 62ºC, a large number of moving particles became apparent near the lower surface of the vapor bubble. Each particle moved in a constant circular mode perpendicular to the length of the vapor bubble; the combined movement of all of the particles defines a cylindrical current (shown in a videotape attachment of Bargar and Keith, 1997). Individual particles appear to bounce off the boundary between water and the vapor bubble, become caught in the continuous current, and then return to the water-vapor interface. The thermal-induced current has a greater velocity at the lower end (right side of Photo 1).Towards the upper end (near center of fluid inclusion) of the short tubular-shaped convective cell, the current velocity appears to gradually decrease, and the particles eventually drift off into the large interior area of the fluid inclusion. Some particles disappear behind the vapor bubble, but they most likely reenter the convective cell because the number of particles within the cell appears to remain nearly constant. As the temperature is reduced, movement of the larger rod-shaped particles decreases until at room temperature only a very slow Brownian-like motion (random movement caused by constant collisions with water molecules) is observed.

Salinity of the water in the fluid inclusion is very low with a Tm value of 0.0ºC. No Th measurement was obtained because heating was discontinued at ~130ºC in order to insure preservation of the very large fluid inclusion (very large fluid inclusions have a slight tendency to break during heating). Fifty-five other liquid-rich, secondary or pseudosecondary fluid inclusions in quartz crystals from the same fracture have Th values between 197º and 373ºC (average of 244ºC); Tm values for 33 of these fluid inclusions is 0.0º or -0.1ºC (salinity = 0.0 to 0.2 weight percent NaCl equivalent) (Table 2).

Similar moving particles were found in liquid-rich, secondary fluid inclusions in quartz crystals from depths of 753.8 m (Th of 253º to 278ºC; Tm of 0.0ºC), 841.6 m (Th of 233º to 265ºC; Tm of 0.0º and -1.7ºC), and 855.0 m (Th of 260º and 289ºC; Tm of 0.0ºC) in the ML 45-36 drill hole.

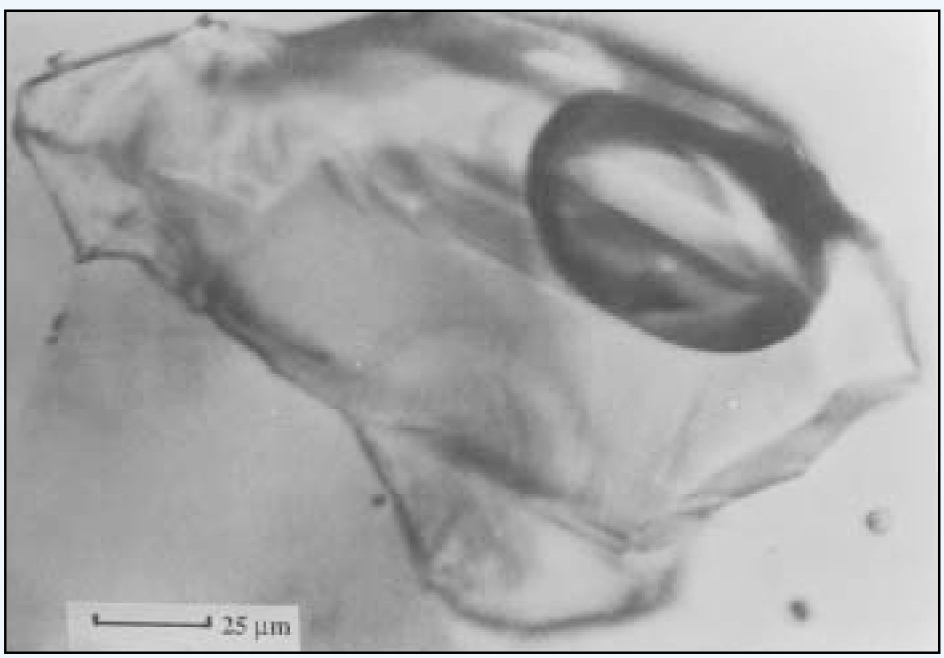


Photo 1. Photomicrograph of a 200 µm x 130 µm liquid-rich, primary fluid inclusion in a 2 mm long colorless quartz crystal from a fracture in a rhyolitic lava flow at 856.2 m depth in the ML 45-36 drill hole. The fluid inclusion contains dozens of tiny moving bacteria-like particles.

DISCUSSION

This study of core samples from 12 geothermal prospect drill holes in the Medicine Lake volcano area identified 44 minerals that must have formed by hydrothermal alteration at low to moderate temperatures. The identified mineral assemblages (zeolites, carbonates, sheet-silicates, silica minerals, sulfides, sulfates, and other minerals) from the drill holes sited outside the caldera of Medicine Lake volcano (Table 1) characterize conditions attributed to zeolite-facies metamorphism (metamorphism occurring under low temperature and pressure conditions). The minerals identified from the upper parts of the two intra-caldera drill holes (Table 1) also appear to reflect the same low-temperature (<200ºC) conditions. It is only near the bottoms of the ML 28-32 and ML 45-36 drill holes that several of the identified minerals (garnet, epidote, actinolite, prehnite, and talc) undoubtedly formed under somewhat higher-temperature (200º to 400ºC) subgreenschist- to greenschist-facies (containing green minerals such as chlorite, epidote and actinolite that formed under low to moderate temperatures and pressures) conditions (Liou, Maruyama, and Cho, 1987).

No fluid inclusions were found in hydrothermal minerals from the drill holes outside the Medicine Lake caldera. Studies of fluid inclusions within quartz and calcite deposits from the ML 28-32 drill hole produced homogenization temperatures (Th) that are mostly characteristic of zeolite-facies metamorphism (Table 2; Figure 3). It is only the presence of the metamorphic minerals garnet, epidote, actinolite, and talc (Table 1) that indicates the existence of past higher temperatures in this drill hole. However, in the ML 45-36 drill hole the Th values for calcite and quartz fluid inclusions predominantly fall in the 200º to >300ºC range (Table 2; Figure 4) characteristic of subgreenschist- to greenschist-facies conditions. The presence of epidote, actinolite, and prehnite (Table 1) provides additional support for higher-temperature metamorphism.

Fluid inclusion studies of several geothermal drill holes in Japan indicate that at a given depth minimum Th values are generally the same or slightly warmer than the present measured temperatures (Taguchi and Hayashi, 1982; Taguchi and others, 1984). These workers indicate that minimum Th values can be used to estimate present-day temperatures where drill-hole temperature-data were not obtained or are unavailable for proprietary reasons. Minimum Th measurements for fluid inclusions in the lower half of the ML 45-36 drill hole (Figure 4) suggest that present-day temperatures in the lower few hundred meters may be near 200ºC. The majority of Th measurements is much higher than 200ºC reflecting much hotter conditions that occurred in the past. In fact, numerous Th values plot above the theoretical reference boiling point curve (dashed line in Figure 4). Fluids trapped within inclusions at any given depth would be liquid-rich at temperatures below the boiling-point curve. Fluid inclusions forming at temperatures hotter than the boiling-point curve at any depth would be expected to be vapor-rich or at least there should be coexisting liquid-rich and vapor-rich fluid inclusions. The fluid inclusions whose Th measurements plot above the boiling-point curve in Figure 4 are only liquid-rich and could not have formed under boiling conditions as would be suggested by this diagram.

A study of fluid inclusions in hydrothermal minerals recovered from drill holes in Yellowstone National Park by Bargar and Fournier (1988a) yielded data similar to the Medicine Lake fluid-inclusion study. That is, Th measurements for liquid-rich fluid inclusions plot above a theoretical reference boiling-point curve. During the late Pleistocene Era (about 45,000-14,000 years ago), the Yellowstone area was covered by hundreds of meters of glacial ice. Because of the additional weight of the ice, any fluid inclusions that formed those many thousands of years ago did so under very different temperature and pressure conditions than exist at the present time. Consequently, a theoretical reference boiling-point curve reflecting the maximum temperature that can be attained in a hot-water

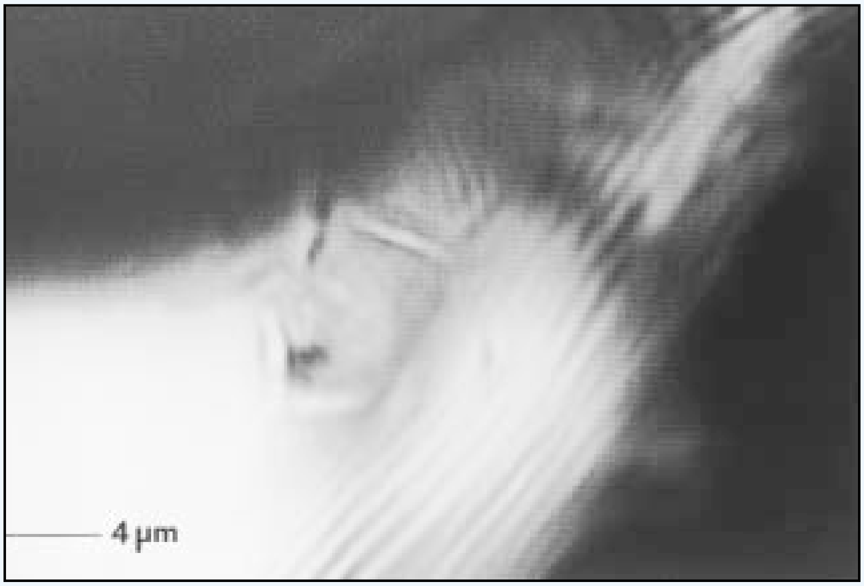


Photo 2. Photograph (using a laser scanning microscope) of tiny, rodlike particles trapped inside the fluid inclusion shown in Photo 1.

system at a given depth in the Pleistocene Era had to have been elevated by several hundred meters above the present-day Yellowstone ground surface. For example, a liquid-rich fluid inclusion in a quartz crystal lining a fracture could have formed at 300ºC under the tremendous overburden of ice. After all the ice melted, that same fluid inclusion with a Th of 300ºC would remain where the present-day temperature of the hot water circulating through the fracture was only 200ºC.

Anderson (1941) and Donnelly-Nolan and Nolan (1986) discussed evidence for about 150 m thickness of Holocene glacial ice in the Medicine Lake volcano area. An additional ground cover of 150 m of glacial ice would require that pore-fluid pressures in the underlying rock be increased in proportion to the weight of the overlying column of ice. According to the above field studies, a theoretical reference boiling-point curve would have to originate approximately 150 m above the present ground surface of 0 m depth (dotted curve in Figure 4) at the time the Medicine Lake area was covered by glaciers. This adjusted boiling-point curve can account for a majority of the anomalous fluid inclusion Th measurements for the ML 45-36 drill hole. A somewhat thicker ice cover would be necessary to account for all of the anomalous Th values. In any event, the fluid-inclusion studies of the ML 45-36 drill core samples appear to support the concept of late Pleistocene glaciation in the Medicine Lake volcano area.

A second aspect of the fluid-inclusion study worth emphasizing are the dozens of tiny (<0.5 to ~ 3 to 5 µm) rod-shaped (Photo 2) and undetermined shaped moving particles that were observed within fluid inclusions in quartz from four depths (753.8, 841.6, 855.0, and 856.2 m) in the ML 45-36 drill hole. These particles apparently were trapped over a period of time during growth of the quartz crystals because the particles occur within primary, pseudosecondary, and secondary liquid-rich fluid inclusions.

Bacteria-like moving particles were trapped within fluid inclusions in hydrothermal quartz crystals that formed on fractures of a 150,000 year old rhyolite lava flow penetrated by a U.S. Geological Survey research drill hole in Lower Geyser Basin, Yellowstone National Park, Wyoming (Bargar, Fournier, and Theodore, 1985) (Th of 190º to 280ºC; Tm of 0.0ºC) In addition to this report, bacteria-like particles in fluid inclusions also have been observed by this author during fluid-inclusion studies of drill-hole specimens from other geothermal areas. Rod-shaped moving particles are present within several liquid-rich fluid inclusions (Th of 249º to 286ºC; Tm of 0.0ºC) in hydrothermal quartz crystals from 1,133-m depth in drill core from The Geysers geothermal area of northern California (Bargar, 1995). A few liquid-rich fluid inclusions (Tm of -0.9ºC; Th of 215º and 241ºC) in hydrothermal quartz crystals from the Miravalles geothermal area, Costa Rica, contain three irregular or rodlike, micrometer-size moving particles (Bargar and Fournier, 1988b). A hydrothermal quartz crystal in one drill-hole sample from the Long Valley, California, geothermal area has two liquid-rich fluid inclusions (Th of 191º and 209ºC; Tm of -0.3ºC) that contain one and two rodlike moving particles, respectively (Bargar, 1995). Also, tiny threadlike and rodlike moving particles were observed in liquid-rich fluid inclusions (Th of 250º and 258ºC; Tm of 0.0ºC) from a fossil geothermal area near Mount Hood, Oregon (Bargar, Keith, and Beeson, 1993).

At the present time, the possibility that the moving particles within these fluid inclusions might be bacteria is highly speculative. The size and shapes of the particles are consistent with that of bacteria, however, attempts to determine by Raman (R.C. Burruss, U.S. Geological Survey, written communication, 1990) and infrared spectroscopy methods if organic material might be present within one of the Yellowstone particle-bearing fluid inclusions were inconclusive. Nonetheless, an inorganic origin for the particles is difficult to envision from a chemical viewpoint. First, a high degree of supersaturation would be required for the simultaneous nucleation of large numbers of particles, and thereafter some special circumstance would have to prevail that prevented growth of large crystals at the expense of the smaller particles. The fluid inclusions studied all have very low salinities which would tend to negate any supersaturation hypothesis. Also, moving particles were trapped in relatively few fluid inclusions; the vast majority of nearby contemporary inclusions do not contain the moving particles. Thus, it seems highly probable that the moving particles (whatever their origin-organic or inorganic) were carried by the fluids from which the quartz crystals precipitated. These particle-bearing fluids flowed through fractures in the rocks, and subsequently, were trapped within fluid inclusions of the precipitating quartz crystals.

If the moving particles within fluid inclusions in quartz crystals from Medicine Lake volcano, Yellowstone National Park, and elsewhere eventually are proven to be bacteria, they somehow must have become adapted to survival at temperatures above 200ºC. The upper temperature limit for life to exist is not presently known but is believed to be between 110ºC (hottest temperature at which bacteria have been conclusively identified) and about 200º or 250ºC (Brock, 1985). On the other hand, thermophilic bacteria are reported to have been collected from a 350ºC “black smoker” hot spring on the East Pacific Rise and grown in the laboratory at 250ºC and elevated pressures (Baross and Deming, 1983). The results from this study were disputed

(Trent, Chastain, and Yayanos, 1984); however, Baross, Deming, and Becker (1984) provided additional amino acid analyses and other data in support of their contention that extreme thermophilic microorganisms do exist.

AUTHOR

Keith Bargar received BA and MS degrees in Geology from San Jose State University. Prior to retiring from the U.S. Geological Survey at Menlo Park in 1995, he spent nearly 25 years studying hydrothermal alteration in geothermal areas of Wyoming, Oregon, California, Hawaii, and Central America. Fluid inclusion analyses were a very valuable tool in these investigations. Presently, he reads novels, swims, rides horses and is continually at his wife's beck and call.

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CALIFORNIA'S NON-FUEL MINERAL PRODUCTION 2000

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Based on the U.S. Geological Survey's (USGS) preliminary data for 2000, California ranked first among the states in non-fuel mineral production, accounting for approximately 8.4% of the United States' total. Mineral production for California amounted to $3.38 billion, about a 1% increase from the previous year. Production of at least 25 types of industrial minerals accounted for about 95% of the total value, with metals accounting for 5% of the total. California was the only producer of boron, rare earth concentrates, and asbestos, and continued to lead the nation in the production of sand and gravel, portland cement, diatomite, and natural sodium sulfate. California ranked third in the nation for gold production behind Nevada and Utah, first and second, respectively. Other minerals produced in California include bentonite clay (including hectorite), common clay, crushed stone, dimension stone, feldspar, fire clay, fuller's earth, gemstones, gypsum, iron ore, kaolin clay, lime, magnesium compounds, perlite, pumice, pyrophyllite, salt, silver, soda ash, talc, and zeolites.

There are about 1,000 active mines producing non-fuel minerals in the state. Approximately 11,090 people are employed at these mines and associated processing plants.

INDUSTRIAL MINERALS

Construction sand and gravel was California's leading industrial mineral with a total value of $1 billion produced for the year, an 11.4% increase from 1999 (final USGS data). Sand and gravel production increased by about 13.6 million tons, or 8.5%. Vulcan Materials Company/Western Division's (formerly Vulcan Materials Company/CalMat Division) Boulevard operation (Los Angeles County) led the state and the nation in sand and gravel production. Portland cement was the second largest industrial mineral produced with a total production of 12.1 million tons valued at about $865 million. Boron, valued at $500 million ranked third, and crushed stone ranked fourth with a value of $403 million.

Teichert Aggregates continued its permitting process for its Lincoln project, a 720-acre aggregate site about 4 miles north of the town of Lincoln (Placer County). The project calls for the extraction of 37 million tons of construction alluvial sand and gravel, and 122 million tons of crushed granite aggregate over a period of 85 years. The final EIR is expected to be completed in the fall of 2001.

CEMEX, Inc. (formerly Transit Mix Concrete Company, a division of Southdown Inc.,) continued its permitting process for the proposed Soledad Canyon sand and gravel mining project (Los Angeles County). If approved, approximately 56 million tons of construction-grade aggregate material will be mined from a 460-acre site over a period of 20 years. The project will also include a concrete batch plant.

Teichert Aggregates and Granite Construction Company received mining permits to extract sand and gravel from the ancestral American River (Sacramento County). Teichert Aggregates' Aspen V South 273-acre site, was permitted in January and Granite Construction Company's 404-acre Vineyard site, was permitted in February.

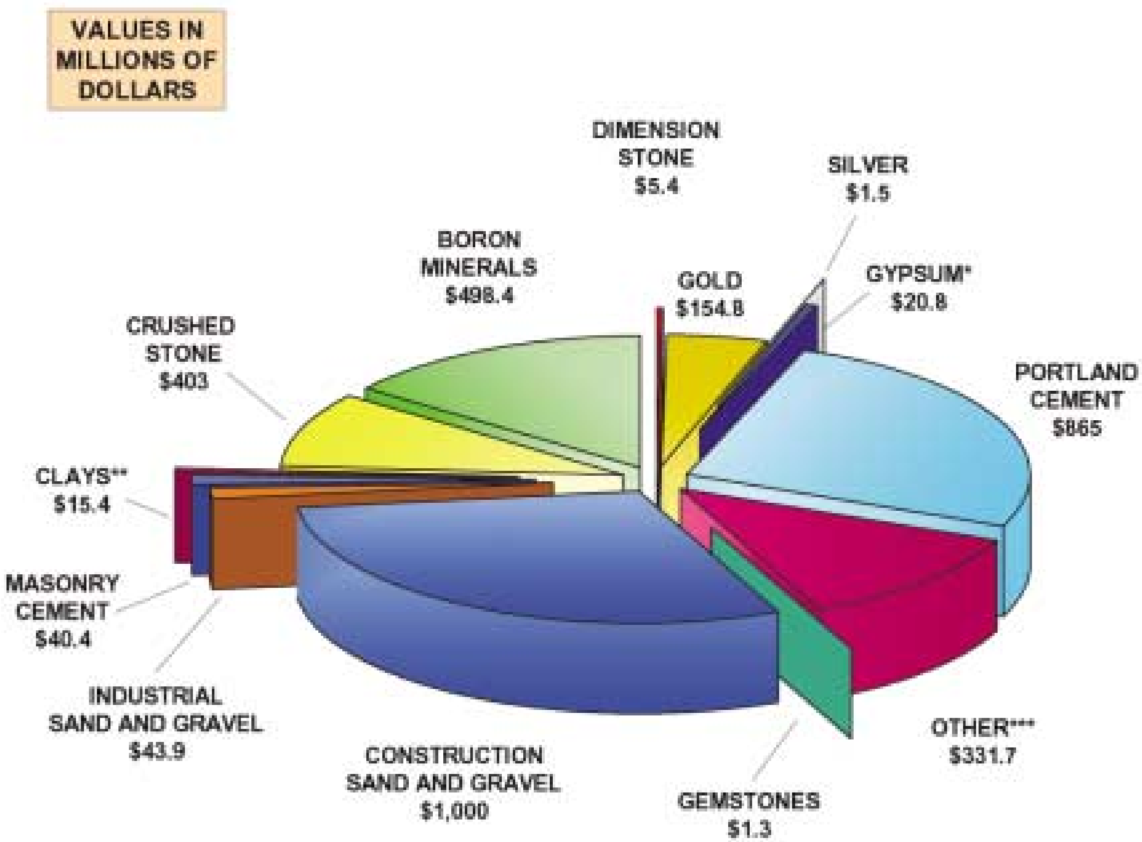
Robertson's Ready Mix was awarded the contract to excavate three pits for the county owned Mid-Valley Sanitary Landfill expansion in the city of Rialto (San Bernardino County). The excavated material is sand and gravel that will be processed on site and sold for construction-grade aggregate. The landfill expansion will provide an estimated 80-100 million tons of aggregate reserves to the San Bernardino area over the 25-35 year life of the landfill.

Molycorp Inc.'s world-class Mountain Pass rare earth mine (San Bernardino County) obtained a temporary permit to mine bastnaesite ore for a 3-month period starting in December 1999. The mined ore kept the plant in operation in a limited capacity through 2000. Molycorp is currently in the process of obtaining a permit to expand its operation. If approved, the new permit will allow for an enlargement of the current pit, and an on-site tailings pond. The Mountain Pass Mine is the only producer of rare earths in the United States.

Calaveras Materials Inc.'s Woolstenhulme Ranch sand and gravel project (Merced County) was granted a permit in November to mine 14 million tons of aggregate over a period of 25-30 years. The material will be processed at Calaveras Materials Inc.'s River Rock Plant near Snelling. Mining began at the site in March 2001.

CALIFORNIA NON-FUEL MINERALS 2000

Total Value $3.38 Billion



Data from U.S. Geological Survey Mineral Information Service (preliminary data)

***OTHER Includes:
Asbestos, diatomite, feldspar, fire clay, fuller's earth, iron ore, kaolin, lime, magnesium compounds, perlite, pumice and pumicite, pyrophyllite, rare earths, salt, soda ash, talc, sodium sulfate and zeolites.

*Data modified from U.S. Geological Survey Mineral Information Service; includes calcined, byproduct and crude gypsum

**Excludes fire clay, kaolin, and fuller's earth

Amount and value of non-fluel mineral production for 1998, 1999, 2000. [1,2]

Mineral		1998 Quantity	1998 Value (thousands $)	1999 Quantity	1999 Value (thousands $)	2000[P] Quantity	2000[P] Value (thousands $)
Asbestos	short tons	6,400	W	7,900	W	6,000	W
Boron Minerals (B_2O_3)	short tons	647,200	496,000	681,300	630,000	691,300	498,400
Cement:							
Masonry	short tons	452,000	39,600	[e]513,800	[e]38,300	540,000	40,000
Portland	short tons	11,044,000	745,900	[e]11,344,700	[e]816,900	12,127,000	865,000
Clays							
Bentonite	short tons	32,000	2,700	33,900	2,500	25,000	2,300
Common	short tons	1,012,000	9,600	1,017,900	9,400	914,000	13,100
Gemstones		NA	1,800	NA	1,100	NA	1,300
Gold[3]	troy ounces	[4]604,000	[4]177,900	562,600	157,400	553,000	154,800
Gypsum[5]	short tons	2,700,900	17,800	3,561,800	18,700	3,920,600	20,800
Rare-earth Metal concentrates	short tons	[e]5,500	[e]14,300	W	W	W	W
Sand and gravel:							
Construction	short tons	148,948,000	800,000	159,505,300	897,300	173,092,000	1,000,000
Industrial	short tons	1,918,000	40,400	1,972,400	43,700	1,991,000	43,900
Silver[3]	troy ounces	707,300	3,600	257,200	1,300	321,500	1,500
Stone:							
Crushed	short tons	60,748,000	344,000	66,452,100	388,200	67,252,000	403,000
Dimension	short tons	31,400	4,700	32,400	4,900	37,379,000	5,400
Combined value of diatomite, feldspar, fire clay, fuller's earth, iron ore (usable), kaolin, lime, magnesium compounds, perlite (crude), pumice and pumicite, salt, soda ash, sodium sulfate, talc and pyrophyllite, zeolites, and values indicated symbol W		XX	289,600	XX	341,500	XX	331,700
Total		XX	2,987,900	XX	3,351,200	XX	3,338,200

[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2]Quantity data are rounded to the nearest 100; values are rounded to the nearest $100,000.

[3]Recoverable content of ores, etc.

[4]Data from California Department of Conservation, Division of Mines and Geology.

[5]Data modified from U.S. Geological Survey Mineral Information Service, includes calcined, byproduct and crude gypsum.

[P]Preliminary. [e]Estimate. NA=Not available. W=Withheld to avoid disclosing company proprietary data; value included with "combined value" data.

XX = Not applicable.

Modified from Mineral Industry Surveys: California, *U.S. Geological Survey.*

Dicalite Minerals Corporation's Lake Britton open-pit diatomite quarry near the town of Burney in northeastern Shasta County. *Photo by Don Dupras.*

METALLIC MINERALS

Newmont Gold Company's Mesquite Mine (Imperial County) continued to lead the state in gold production for the year. Homestake's McLaughlin Mine (Napa, Lake, and Yolo counties) was the second largest gold producer in the state followed by Viceroy Gold Corporation's Castle Mountain Mine (San Bernardino County).

The Newmont Gold Company ceased mining at the Mesquite Mine in the fall. Approximately 3 million ounces of gold has been produced from the mine since production began in 1986. Residual heap leaching will continue into 2003.

The U.S. Bureau of Land Management (BLM) recommended rejection of the proposed Glamis Imperial gold mine project (Imperial County) in a November final environmental impact report. The BLM reports that the project would cause significant adverse impacts to Native American archeological and cultural resources. Glamis Imperial Corp. has spent about $14.2 million on the mine project, which began the permitting process in 1996.

Other metallic minerals produced in the state include silver and iron. All the iron produced in 2000 was used in the production of portland cement. All silver produced was a byproduct of gold production.

MINING EVENTS

West Coast Aggregate's Freeman Quarry (Santa Clara County) began mining operations in July. Construction of a permanent plant site is expected to begin in the summer of 2002.

The Granite Rock Company celebrated its 100-year anniversary in February. The celebration marked the 100th year of continuous operation at the A.R. Wilson Quarry (San Benito County). The Wilson Quarry is California's largest rock quarry.

CEMEX, Inc. (formerly Southdown Inc.) opened its new cement terminal in Sacramento in June. The facility has a holding capacity of 8,000 tons. This state-of-the-art facility features automatic and dust free loading technology. Cement is transported by rail over 400 miles from CEMEX's Victorville Plant in San Bernardino County.

ACQUISITIONS AND NAME CHANGES

CEMEX, Inc., a large Mexico-based company, purchased Southdown, Inc.for $2.6 billion in November. The acquisition included: Southdown, Inc.'s Victorville cement plant, the Black Mountain, White Mountain, and Alvic limestone quarries in Apple Valley (San

Excavating auriferous sand and gravel at Teichert Aggregate's Aspen VI Pit, north-central Sacramento County. The conveyor system carries the pit run material over 5 miles to the processing plant. *Photo by Don Dupras.*

Bernardino County), the Quartzite Mountain silica deposit near Victorville (San Bernardino County), the Transit Mixed Azusa sand and gravel mine (Los Angeles County), and the Transit Mixed Concrete Moorpark sand and gravel mine (Ventura County). CEMEX, Inc.'s newly acquired Victorville cement plant is undergoing a 1-million-ton-per-year plant expansion, which will raise the plant capacity to 3.2 million tons per year. The expansion is expected to be operational in the fall of 2001.

United Metro Materials acquired Solano Concrete Company, Inc. The purchase included a 1-million-ton-per-year sand and gravel mine (Yolo County), an asphalt plant, and two ready-mix plants in northern California.

Vulcan Materials/Cal Mat Division officially changed its name to Vulcan Western Division. Vulcan Materials acquired Cal Mat in January 1999.

RMC Lonestar changed its name to RMC Pacific Materials in January.

Rheox, owner of the Hectorite Mine (San Bernardino County) officially changed its name to Elementis Specialties in July. Rheox was acquired by Elementis in January 1998. The Hectorite Mine is believed to contain the world's largest commercial deposit of hectorite clay.

MINE AND PLANT CLOSURES

The Weber Creek rock quarry (El Dorado County) was ordered by the county to stop operations in June. The order came after a very long controversial battle between local government, state, and private industry concerning the enforcement of the Surface Mining and Reclamation Act (SMARA).

Avocet Tungsten, Inc.'s Pine Creek Mine (Inyo County) shut down its ore processing plant in July. The company cited competition from foreign sources and the U.S. government selling of stockpiled ore as the main reasons for its closure. No mining has taken place since the mine closed in 1990.

LEGISLATION

On July 20th, the California Air Resources Board (CARB) eliminated the use of any ultramafic rock containing detectable (0.25 %) asbestos for road surfacing and landscaping. The measure came after the Environmental Protection Agency (EPA) found high levels of asbestos in the air around gravel roads in El Dorado and Calaveras counties. CARB initiated a similar measure in 1990, limiting the asbestos content in surfacing rock to 5%. Asbestos-containing rock can still be used for non-surface applications such as riprap, road base, and drain rock.

California's aggregate demand is expected to increase considerably with Governor Davis' Traffic Congestion Relief Plan. The plan, announced in April, will fund nearly 100 high-priority transportation projects throughout the state at a cost of $5.3 billion. The anticipated increase in aggregate demand has sparked an aggregate rush throughout the state, particularly in the Los Angeles and San Francisco Bay regions where about 70% of the funds will be allocated.

MINERAL RESOURCE CONSERVATION

Siting and permitting of mine operations throughout the state continue to be locally controversial. The leading issues include intense land use competition, wide ranging environmental concerns, surface water and groundwater issues, as well as noise, dust, and truck-traffic in populated areas. The California Department of Conservation's Division of Mines and Geology (DOC/DMG) Mineral Land Classification Project (a mandate of SMARA) continues to provide lead agencies with mineral resource maps, which have proved to be of great value in land-use planning and mineral conservation. In 2000, DMG completed Mineral Land Classification reports of mineral resources in El Dorado, Kern, and Tehama counties. During 2000, classification projects were ongoing in Lassen, Solano, Napa, Sonoma, Marin and San Bernardino counties. In addition to the ongoing classification reports, DMG has been developing a statewide aggregate resource and demand map.

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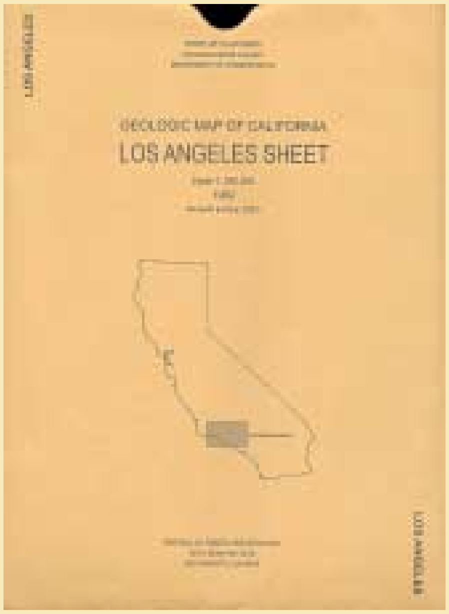

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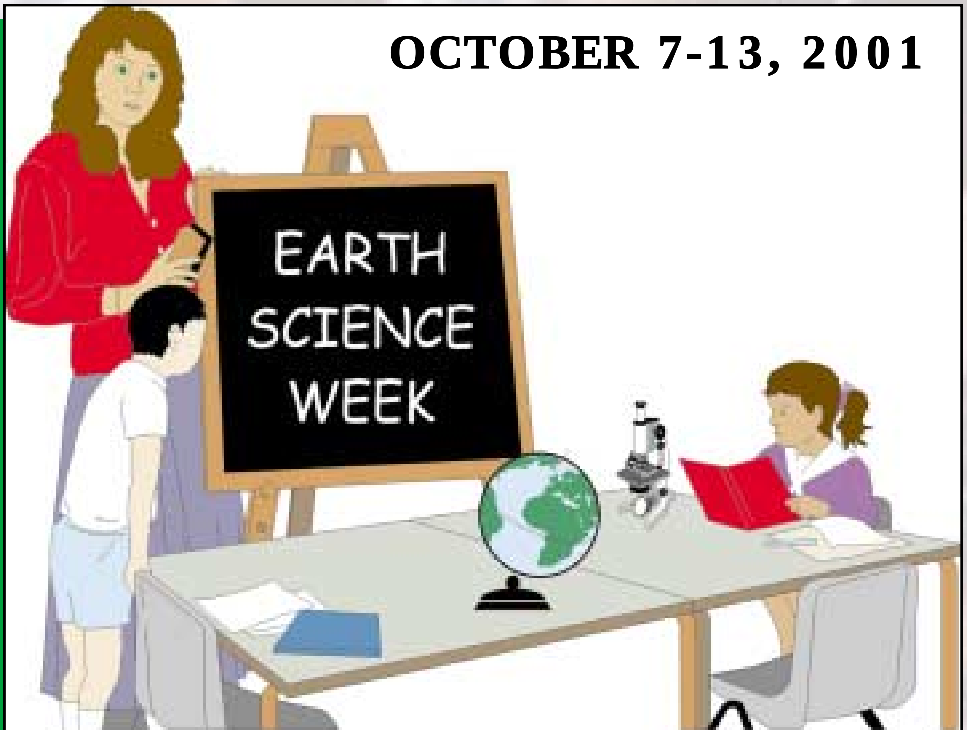


GOALS OF EARTH SCIENCE WEEK

- To give students new opportunities to discover the earth sciences.
- To highlight the contributions that the earth sciences make to society.
- To publicize the message that earth science is all around us.
- To encourage stewardship of the earth through an understanding of earth processes.
- To develop a mechanism for geoscientists to share their knowledge and enthusiasm about the earth and how it works.
- To have fun!!!!!!!!!!!!

HOW YOU CAN GET INVOLVED IN EARTH SCIENCE WEEK (OCTOBER 7-13, 2001)

Here are several ideas to get you started...

EARTH SCIENCE FAIR

Host an earth science fair at a local school. A science fair can be a great opportunity for students to practice earth science, especially after hearing a geoscientist speak about his or her current research projects. Invite teachers and local geoscientists to be the judges. Encourage students to participate in the fair by offering awards such as posters, geoscience books, or even savings bonds. Recognize the young earth scientists by publishing their names in a local newspaper.

A DAY AT THE BEACH

Visit beaches to watch erosion processes and wave energy in action, then pick up the trash washed ashore.

ACTING OUT

Arrange with a local youth theater organization to prepare a skit about community issues relating to earth science. The students can perform the skits during Earth Science Week at local museums or community centers.

EARTH SCIENCE ESSAYS

Organize an essay contest on the topic "How earth science affects our community." Get local business and companies to donate prizes or scholarship awards for the contest. Make the project interdisciplinary by having students illustrate their work.

FILM FESTIVAL

Arrange to have a film festival at a local school: advertise, get sodas and popcorn, and showcase some films with earth science themes. Check out videos from a local geological society of the geoscience department of a university, or show some big screen blockbusters to examine who earth science is a part of popular culture and entertainment.

EARTH SCIENCE ARTISTS

Volunteers may paint a mural on a building in town, showing how earth science is integrated into the town landscape.

EARTH SCIENCE CAREER FAIR/COLLEGE FAIR

Hold a career fair and invite geoscientists and college and university geoscience departments to participate.

PICTURING THE EARTH

Organize an earth theme photo contest and display the photos at a local library, community center, or business. Prizes could be free photo equipment and/or processing.

UNDERSTANDING RESOURCES

Hold a tour or open house at a mine, quarry, water works, or utility plant. Invite elementary, middle, and high school students to learn about natural resources and mining on-site.

Alaina Taylor visits DMG's seismic center to gather information for her high school career day project. She also interviewed seismologist Vladimir Graizer. *Photo by Max Flanery.*

Earth Science Week

DMG's Joy Arthur (research analyst) and Max Flanery (outreach coordinator) field questions at the booth at the State Scientist Day fair in Sacramento. *Photo by Don Drysdale.*

DMG geologists, Cindy Pridmore and Ed Kiessling, present map at the American Association of Petroleum Geologists/Geological Society of America Conference. *Photo by Max Flanery.*

ADOPT-A-TEACHER

Sponsor a workshop that gives educators the opportunity to perform earth science activities under the guidance of experienced demonstrators.

EARTH SCIENCE FOR COMMUTERS

Hold an annual poster contest for area school students as a part of Earth Science Week. Arrange for the winning entry to be displayed in buses and other public transportation during October.

EARTH SCIENCE IN YOUR COMMUNITY

Conduct a field trip in a park or on a campus.

OPEN HOUSE

During Earth Science Week a number of state geological surveys, geoscience societies, and businesses will host open houses for the general public.

EXHIBITS

Set up an earth-related exhibit or display of minerals, rocks, or fossils in a public location such as a shopping center, museum, library or building lobby.

SCOUTS, CAMPFIRE, 4-H LEADERS

Focus on badges and projects that celebrate earth science.

AFTER SCHOOL ACTIVITIES

Organize after school activities at day-care centers, schools, or YMCAs around an earth science theme.

EARTH SCIENTISTS AT WORK

Invite local K-12 and university students to attend an open house at an earth science-related company, association or government agency.

EARTH SCIENTISTS IN THE CLASSROOM

Volunteer to visit a classroom, lead an earth science activity, conduct a demonstration, or talk about your career.

Student intern April Wood works at the DMG Library age appropriate earth science materials. *Photo by*

BUILDING STONE TOUR

Conduct an urban walking tour to observe the many different types of building stones in use. Create maps and corresponding descriptions of the building stones at each site.

GETTING EARTH SCIENCE ON THE BOOKS

Arrange an Earth Science Week display at your local library, and create a book list of earth science books available all year around. Your can also have an earth science book fair at a school

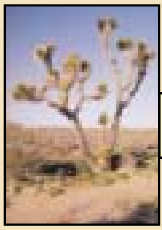
The American Geological Institute, a not-for-profit federation of 34 professional societies, established an annual Earth Science Week in 1998. Earth Science Week will be celebrated each year during the second full week of October.

For more information, contact:

American Geological Institute
4220 King Street
Alexandria, VA 22302
www.agiweb.org

Teacher Resource Center guiding teachers toward
Max Flanery.

Bethany Perez “shows off” one of the many DMG products used by teachers and students. *Photo by Max Flanery.*



TWO GEOLOGY TOURS OFFERED BY THE DESERT INSTITUTE

Joshua Tree National Park

ANCIENT SURFACES/ANCIENT LAKES OF THE MOJAVE DESERT

Two Saturdays: October 27 and November 3, 2001: 8:30 am - 5:00 pm
Location: Black Rock Ranger Station, Yucca Valley
Instructor: Bob Reynolds: Project Manager/Paleontologist for LSA Associates, Riverside, California
Fee: $100 ($80 for JTNPA members)

On the first day we'll look at stable Miocene surfaces—the same surfaces that have been ruptured by faults. We'll investigate evidence for Miocene lakes that filled the faulted and extended terrain. The trip will compare Miocene lakes with lakes filled during the Ice Ages. On the second day we'll look at extensional structures and topography such as the Cima Dome, cinder cones and basalt flows.

THE LANDERS EARTHQUAKE FAULT TOUR

Saturday: November 10, 2001: 9:00 am - 4:00 pm
Location: Black Rock Ranger Station
Instructor: Bob Reynolds, Paleontologist
Fee: $50 ($40 for JTNPA members)

The tour will look at rupture damage and scarps that still exist from the Landers quake. The faults cut ancient Miocene age surfaces seen from Pioneertown to Soggy Lake. We'll see and discuss evidence that the Hector Mine quake reactivated sections of the Emerson Fault in 1999. Fence lines, boulder slopes, scarps, and even empty foundations still show visible signs of damage. This evidence lets us imagine the destructive forces unleashed by the earthquake.

— For more information contact The Desert Institute at Joshua Tree National Park, 760-367-5535.

— Visit us on the web at www.joshuatree.org and click on Desert Institute.

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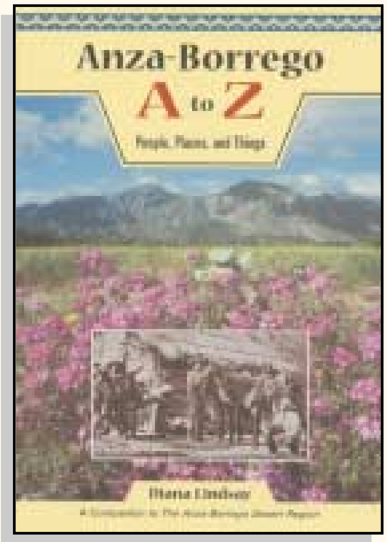

ANZA-BORREGO A TO Z
By Diana Lindsay. 2000. Sunbelt Publications. 400 p. 800-626-6579.
E-mail sunbeltpub@prodigy.net
ISBN 0-932653-38-3

Whether you are an avid armchair explorer or a hands-on hiker, this compact book provides captivating entries of people, places and events of the Anza-Borrego Desert region in southern California. More than 25 years' worth of research on the history and culture of the region sets the stage for Diana Lindsay to reveal a user friendly encyclopedic dictionary of place names, natural history, and "unforgettably colorful tales from the traditions of desert lore." Designed to complement the guide book *The Anza-Borrego Desert Region* (Wilderness Press) for which Lindsay is a co-author, *Anza-Borrego A to Z* provides more than 750 entries linked to other entries to provide depth and dimension without being repetitive. Whether or not you've visited this special part of California before, it makes you want to pull out a map and start an intriguing desert journey full of local and natural history.

Lindsay's interest in the Anza-Borrego Desert dates back to the late 1960s when she wrote several research papers on the region as a history major at San Diego State University. Through the years Lindsay and her husband, geologist Lowell Lindsay, have extensively explored the Anza-Borrego Desert State Park and its surrounding areas. As a way of thanking the park for all that it has given her, the author's royalties for *Anza-Borrego A to Z* will be donated to the Anza-Borrego Foundation.

Reviewed by C.L. Pridmore, Associate Engineering Geologist, DMG.

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Saurolophus angustirostris feet. Lense cap for scale. *Photo by Max Flanery.*

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